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# Modelling of the heat loads of the engine valves and the accuracy of calculations

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**Analysis and modelling**

## ABSTRACT

**Purpose:** The qualification of influence of received step of analysis in numeric calculations on the value and distribution of the temperature in the inlet and outlet valve in the turbo Diesel engine in initial phase its work.
**Design/methodology/approach:** The results of calculations of the value and distribution temperature in the valves in turbo Diesel engine received by means of the two zone combustion model and the finite element method.
**Findings:** The carried out calculation present, that the selection of the step of analysis in the finite element method by used of the variable values of the boundary conditions and temperature working medium in the engine cylinder influences on the value and the temperature distribution on individual surfaces of the valves.
**Research limitations/implications:** The modeling of the heat loads of the inlet and outlet valves was executed for two steps of the analysis in initial phase of the work of turbo Diesel engine. The obtainment the full opinion of the results of numeric calculations would require more operation for larger compartment of the time, until to the moment of achievement by the valves of temperatures during the stabilized work of engine.
**Originality/value:** The results of numeric calculations of the heat loads of the valves displayed the large influence of the received step of analysis on achieved values and temperature distribution on individual surfaces these elements. This state the supplement of message on subject of course modeling the processes of flow of the heat and the same show on problem and way their running by use of the finite element method by means of variables values of the boundary conditions and temperature of working medium.
**Keywords:** Numerical techniques; Heat loads of the valves; FEM

## 1. Introduction

The present work attempts to answer the question concerning the influence of received step of analysis on the results obtained by use of the numeric computations based on the finite element method [1]. The analysis issue was conducted on example of the loads of heat in the inlet and outlet valves in the turbo Diesel engine with direct injection to the combustion chamber. The purpose of the calculations was to supplement the message about the course of modeling the processes of the flow of the heat in the valves and the same received of the proper values and distribution of temperature on these individual surfaces. The essence of the problem, first of all, displays the use of the variable values of the shore conditions as well as variable values of the temperature working medium in the engine cylinder. The Selection of suitable numbers of the values in the conducted calculation isn't influenced only by economics, but mainly on the obtainment of the correct results during the modeling of the loads of the heat valves. Further information about of the heat loads of the valves the reader can be found in Ref. [2-3].

## 2. Modelling of the heat load

The modeling of the heat loads inlet and outlet valves were applied the III kind boundary conditions which characterizes the temperature T working medium, appointed on the basis of the course indicated pressure (fig.1) by using the two zone combustion model [3-8] as well as the coefficient of the heat transfer (fig.2) in the engine. The analysis of the distribution temperatures was carried out in 40 [s] worktime engine to the time when one changed in small range.

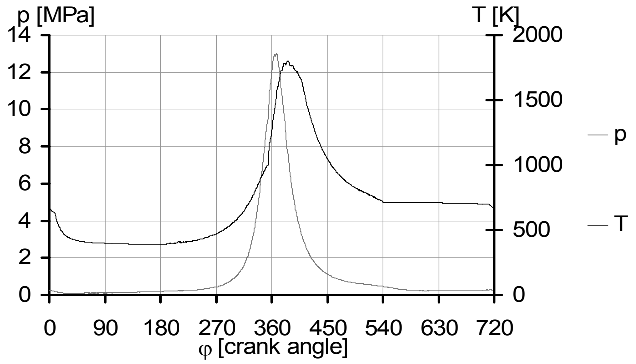


Fig. 1. The course of pressure and temperature of working medium in turbo Diesel engine (N = 85 kW , n = 4250[rpm]) [4]

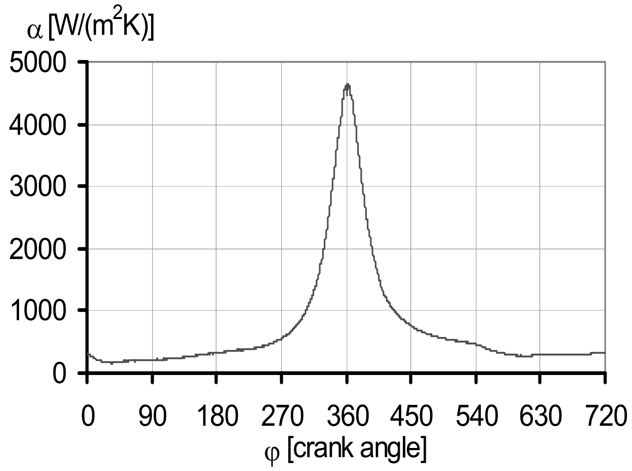


Fig. 2. The course of changes of total heat transfer coefficient in the speed engine function for 4250 [rpm] and the access air coefficient $\lambda = 1{,}69$

## 3. Explicitness conditions

In the case analysis of the unestablished heat transfer in the valves it should consider the explicit conditions [7] to which geometrical , physical and initial conditions belong.

### 3.1. Geometrical conditions

Geometrical conditions describe shapes and sizes of the considered body. The analyzed geometrical models of the valves were executed by the means of tetrahedral units lump 3-dimension about 4 knots (TETRA 4) and accessible dimensions 1[mm] in the system Cosmos / M [3].

### 3.2. The physical conditions

These conditions define the physical properties of the substance created by the body, namely density , proper heat capacity and also thermal coefficient conductance [3].

On the inlet valve was accepted constructional steel to toughening 40H [12], however on the outlet valve chromium-nickelsteel 5H13N15W2 [3,7,9,10]. The program COSMOS/ M makes possible for use of the curves of the temperatures in the thermal analysis [3]. For the inlet and outlet valve accepted by the variable value of thermal coefficient conductance in function of temperature T (fig. 3) [12].

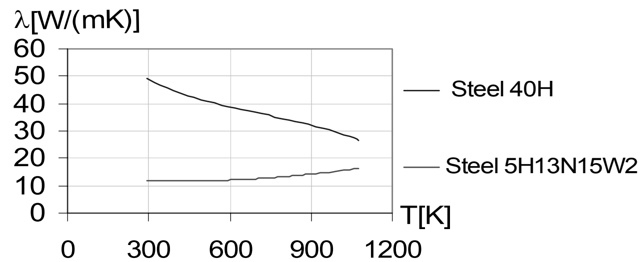


Fig. 3. The courses of changes of thermal coefficient conductance of the steel outlet valve - 5H13N15W2 and inlet valve - 40H in the temperature function [12]

### 3.3. Initial conditions

The Initial conditions defined in whole, were occupied by body temperature distribution in the initial moment of the time $\tau=0$. During the heat loads analysis there were constant temperature distributions and even the ambient temperature [7].

### 3.4. Boundary conditions

During the analysis of the influence load on the value and temperature distribution in the valves, the following surfaces were considered (fig. 4): the plate (1), the valve face (2),

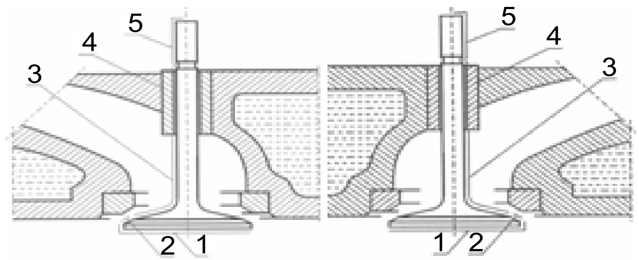


Fig. 4. Drawing of the inlet and outlet valve in the engine head [3] valve spindle in the inlet channel (3), face surface of the valve spindle in the engine head (4) and surface of the valve spindle over the head (5)

## 4. Results of calculations

This work has introduced the heat loads of the inlet and outlet valve in turbo Diesel engine with direct injection to the combustion chamber with the capacity of about 2390[$cm^3$] and power rating 85[KW] at the speed of 4000 [rpm].

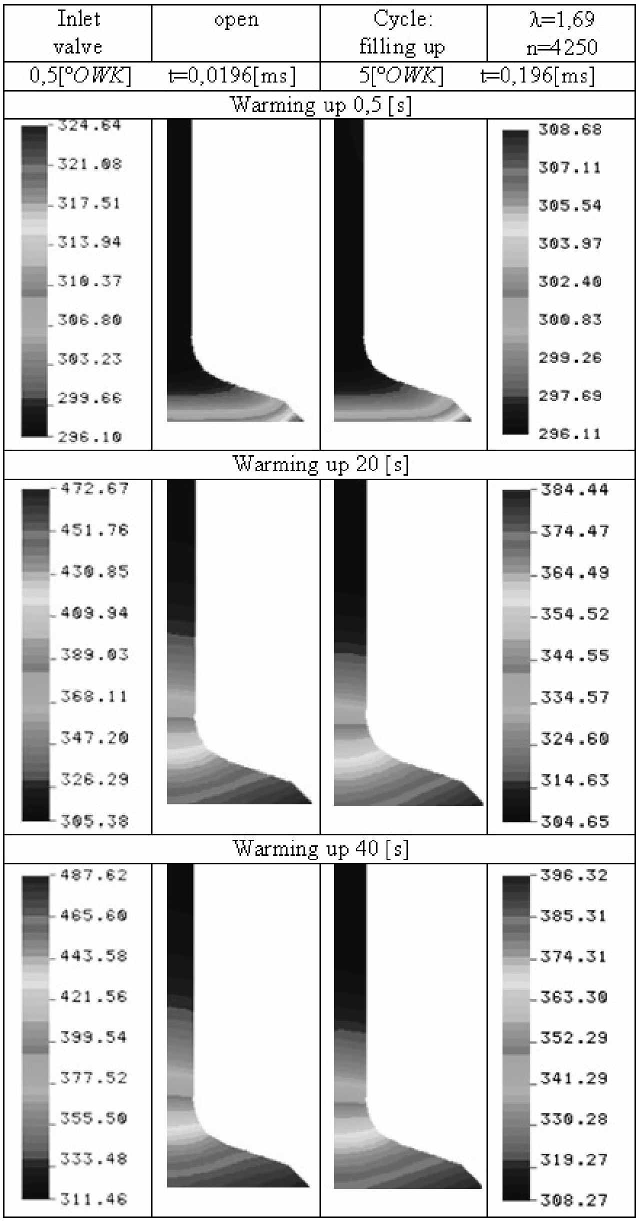


Fig. 5. The following phases warming up of the inlet valve

The computations were carried out with accuracy 0,5[crank angle] and 5 [crank angle] for the same the engine loads and the engine speed of 4000[rpm]. Figures 5 and 6 presented the following phases of the warm up of the valves responding the

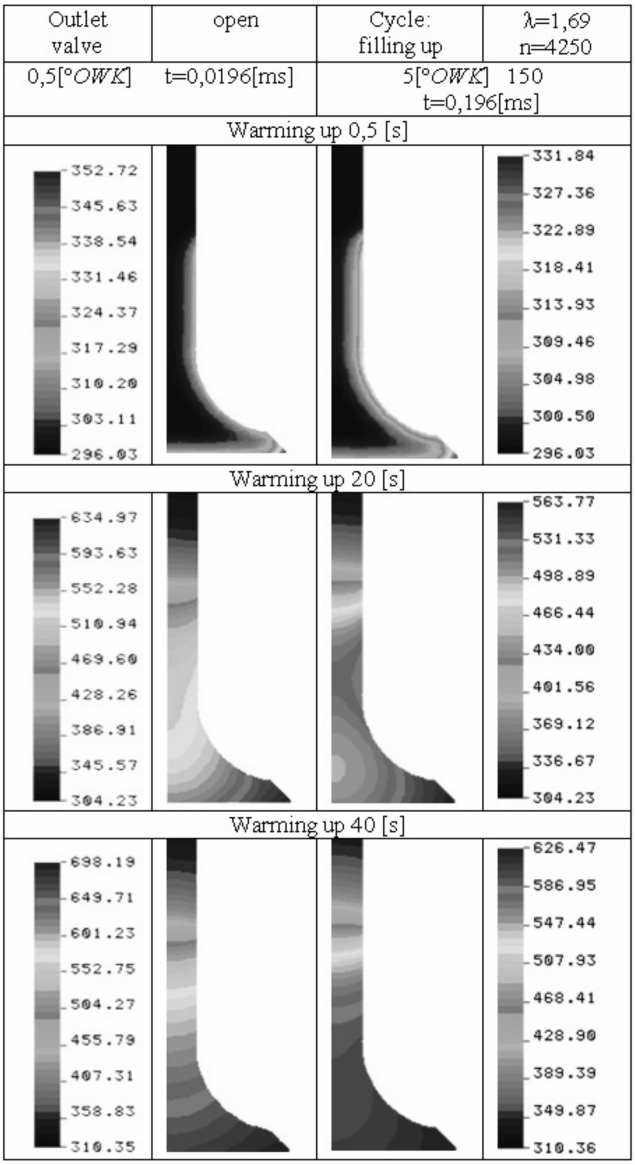


Fig. 6. The following phases warming up of the outlet valve

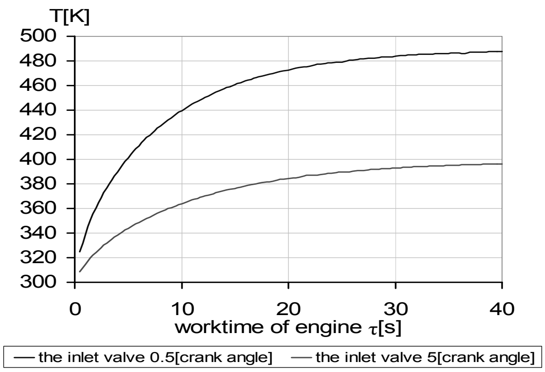


Fig. 7. The course of changes of the maximum temperature inlet valve

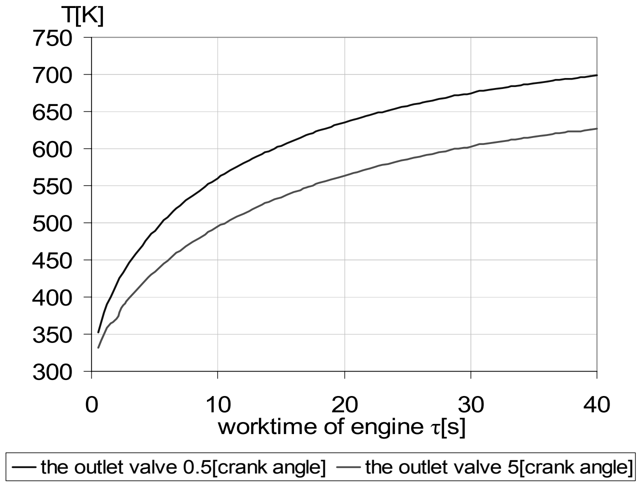


Fig. 8. The course of changes of the maximum temperature outlet valve

piston position carrying out 5[crank angle] after inner dead centre (the cycle filling up - the open valve) after 0,5[s], 20[s] and 40[s] of the work of the turbo Diesel engine.

The course of changes in the maximum temperature inlet and outlet valves for two steps of the analysis was introduced in fig.7 and 8, however the composition of the characteristic temperatures for the individual valves surfaces was contained in table 1 after the work engine carried out 40 [s].

Table 1.
The characteristic temperatures for the individual surfaces of the inlet and outlet valve

| Temperature [K] | Step of analysis 0,5[crank angle] | Step of analysis 5[crank angle] |
|---|---|---|
| inlet valve | | |
| Maximum of the valve | 488 | 397 |
| Average whole of the valve | 387 | 345 |
| Average of the plate valve | 457 | 393 |
| Average of the face valve | 482 | 393 |
| outlet valve | | |
| Maximum of the valve | 699 | 627 |
| Average whole of the valve | 494 | 470 |
| Average of the plate valve | 684 | 618 |
| Average of the face valve | 695 | 626 |

## 5. Conclusions

On the basis of the conducted model of the heat loads of the valves affirmed, that the step of analysis applied for the variable values of the shore conditions exchange of the heat, as well as the course of the temperature of working medium has the essential influence on the results of the computations received by means of the finite element method. In the case of the outlet valve, the value of the maximum temperature differed at about 12%. The inlet valve's maximum temperature differed at about 22%. The enlargement of the accuracy calculations influenced the speed of the warming up of the valves as well. The difference among the maximum speeds of warming up carried out for inlet valve at about 16[K/s] and for outlet valve at about 21[K/s]. Moreover, the outlet valve underwent large difference in the distribution of the temperatures on the it's individual surfaces.

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